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CNRS Selection Committee

To Whom It May Concern:

It is my pleasure to offer my strongest support of **Dr. David Demory**'s application to initiate a Chargé de Recherche de Classe Norrmale within CNRS. Dr. Demory started as a postdoctoral fellow in my group at Georgia Tech in October 2017 and has excelled in all respects, building on his training in oceanography and virus dynamics to establish genuine leadership in multiple projects that span theory, simulation, experiments, and field work. He has a unique set of skills that will enable him to establish a group, advise students, and develop research programs of interest to colleagues and funding agencies. I am confident that Dr. Demory is ready for this transition to independence.

As a postdoc at Georgia Tech, David has made a rapidly expanding set of contributions, has made multiple, significant research discoveries regarding the roles of marine viruses in shaping population dynamics and ecosystem functioning at high temporal resolution, and has demonstrated significant leadership both as a mentor to PhD students and in shaping new research directions in marine impacts on surface ocean communities in the North Pacific Subtropical Gyre. David has also played critical roles in rapid response models of Covid-19 interventions, and although this work is not the centerpiece of his research proposal; his contributions have enhanced his ability to work on collaborative teams in response to global needs (including a paper that was published by my team in Nature Medicine earlier in 2020). In my team, David has established himself as the group's *de facto* hands-on expert for model-data integration using MCMC and other computational methods. That set of skills means that David's trainees will be well poised for rigorous, data-driven research. In sum, David is a smart, talented, and committed marine microbial ecologist who is on track for a highly productive and dynamic career at the interface between microbial ecology, marine science, and modeling.

David joined my group after completing his Ph.D. in Oceanography with Prof. Anne-Claire Baudoux at the Roscoff Biological Station. His Ph.D. projects on marine picophytoplankton, viruses, and their interactions combines modeling and experimental work motivated by critical challenges in aquatic ecology. His thesis work resulted in multiple findings, including a novel temperature dependence modulating the outcome of virus-*Micromonas* infections (Demory et al., ISME J 2017) and forecast models of global warming impacts on picophytoplankton (Demory et al. ISMEJ 2018). His Ph.D. work is particularly notable for inclusion of statistical methods to link nonlinear model predictions with data. This work reflects his practical, hands-on experience in the field and his desire to ensure that models are a means – not just an end – to discover relevant, *in situ* mechanisms.

As a postdoc at Georgia Tech, David has made major contributions in multiple areas of marine viral dynamics. First, David led a recently published analysis of how light-driven variation in viral life history traits at a cellular scale modulate population dynamics of both cyanobacteria and cyanophage (Demory et al. mSystems 2020). Second, David extended his PhD work to show how temperature driven variation in viral life history traits may lead to fundamental shifts in Micromonas-virus dynamics in changing climate scenarios (Demory et al., Ecology Letters, provisional acceptance). Third, David is the co-lead of a major project estimating the relative impacts of viruses and zooplankton in controlling *Prochlorococcus* population dynamics in the NPSG (Beckett, Demory, et al., in prep for submission in early 2021). Finally, David leveraged his pre-existing research connections to identify a cruise of opportunity in Fall 2018 in the SW Pacific Ocean and then collected high-resolution water samples for polony-measurements of

strain-specific infections. Initial data from this project reveals the importance of cyanophage of Synechococcus in the Chatham Rise (largely unstudied for viruses). Below, I describe some of what David has accomplished thus far, and how his proposed work is primed for success.

Linking environment-dependent viral life history traits to population-level dynamics: As a new postdoc at GT, David began to develop a flexible diel-driven model of virus-plankton interactions. The aim of the model was to evaluate how light-sensitive viral infections could transform both viral and microbial population dynamics. The timing was ideal. Soon after starting the project, we learned that Prof. Qinglu Zeng (Assoc. Prof., HKUST) – a former postdoc of Prof. Penny Chisholm – had posted a biorxiv article including multi-day experimental data showing evidence of light-sensitive cyanophage life history traits. (Of note, the core findings of this biorxiv article form the basis for a PNAS led by the Zeng group solely). However, it remained unclear then, and now, if such light-dependent traits have a direct influence on host and virus *population* dynamics, given that host physiology is itself modulated by light. Using a Markov Chain Monte Carlo model-data fitting approach, David demonstrated that light-dependent differences in adsorption can explain population-level dynamics for some, but not all, phage-bacteria strains – this finding both confirms and extends the results of the Zeng group beyond cellular level effects to the scale of populations. But, perhaps even more interesting is that light is not the only explanatory factor. David's analysis approach identified the potential for substantial decreases in lysis rates at relatively high viral densities that modulate system behavior (Demory et al., mSystems 2020). This work exemplifies David's strong intuition for how marine organisms interact, technical rigour, and a passion for connecting models and data. Indeed, David has developed this same theme in his work on temperature-dependent changes in life history traits for viruses that infect Micromonas. Leveraging data taken during his PhD, David has shown both how such temperature dependent traits can explain population dynamics, but how virus-microbe relationships may be inexorably altered in light of climate change scenarios (Demory et al., Ecology Letters, provisionally accepted). Moving forward, David's proposed exploration of the intersection of physiology and population dynamics in a changing ocean will be a significant step forward for the field, in which viral plasticity is an increasingly important theme.

Quantifying infection of picoplankton in the field: David has long-standing ties to the Pacific, having grown up in New Caledonia and worked and volunteered in New Caledonia and Australia on fishery-related projects. His long-term aims are to deepen understanding of viral impacts on picophytoplankton, including infections of both dominant cyanobacteria and eukaryotic phytoplankton. In early 2018 he identified a means to explore virus impacts in dominant picophytoplankton near the Chatham rise in the Southwestern Pacific Ocean. The Chatham rise is a shallow oceanic plateau off the coast of New Zealand, that separates subtropical waters from sub-Antarctic waters to the south. Hence, distinct oceanic regimes can be sampled in a relatively small geographic area. The Chatham rise is also characterized by a dominant *Synechococcus* community, almost entirely uncharacterized in terms of virus-host dynamics. David reached out to the lead scientist of the cruise, and developed a plan to intensively sample waters to estimate cellular levels of infection of *Syn* and dominant picoeukaryotes in the long term. David co-organized a rapid, seed grant proposal through GT and then a follow-up proposal to the Simons Foundation. Both were funded, the samples were collected, and then David travelled to Haifa in 2019 to perform the required polony experiments. Although the subsequent experiments were delayed by Covid-19, the initial data is sufficiently novel that I anticipate a key first publication characterizing diel dynamics of cyanophage of *Synechococcus.* Moreover, this kind of initiative and diversity in thinking is rare irrespective of career stage, and reinforces the justification for David to secure multi-year independent support. This project is poised to yield altogether new, empirically-based field estimates of viral infection – complemented by community-wide assessment of diversity – that can also help in developing predictive models of virus impacts in the present ocean.

Connecting cellular and population models to understand viral effects on ecosystem function: I recruited David to join my group to support and extend modeling efforts focusing on the interplay between top-down and bottom-up effects in structuring population dynamics and ecosystem functioning

at Station ALOHA – as part of the 'SCOPE' collaboration. The inaugural SCOPE cruise in Summer 2015 featured an intensive sampling scheme that yielded concurrent measurements of organisms, metabolites, elements and processes through the diel cycle over multiple days in a single, coherent body of water. Despite multiple high-profile papers that have arisen via this cruise, a major set of questions remains unanswered, e.g., to what extent should diurnal rhythms at the base of the microbial food web propagate through the food web and ecosystem including heterotrophs, viruses, zooplankton, and nutrients? In response, David has emerged as a critical, co-lead with another postdoc in my group – Dr. Stephen Beckett – in developing a new size-structured phytoplankton model linked to a multi-trophic food and parasite web; what we call the Ecological Community with Light, Infection and Phytoplankton Size-Structure (ECLIPSS) model. Indeed, David's work helped to enable a major breakthrough in this effort. Prior fits of ECLIIPSS suggested that presumed, joint effects of grazers and viruses were incompatible with the quantitative nature of observed oscillations. Together, we recognized that grazer growth may be decoupled, at least in part, from *Pro* densities. Incorporating 'generalized grazing' has led to a striking result: we now have nearly spot-on fits for the dynamics of total *Pro*, *Pro* size structure, timing of size structure oscillations, grazer densities, POC, and even viral infection/numbers. We are now in the final stages of preparing a manuscript for submission in early 2021. In doing so, this paper will make a number of major contributions: (i) reinforcing a recent finding that viral lysis is relatively unimportant in driving mortality of *Prochlorococcus* in the NPSG; (ii) a multi-trophic model can fit data on phytoplankton size as well as virus density, infection, and nanoflagellate grazing; (iii) that the sum of viral-induced mortality and grazing does not fully explain inferred loss rates of *Prochlorococcus*. This last provocative finding is a direct result of an integrative analysis of the entire system and has the potential to change assumptions of the relative role of top-down mortality, while spurring new experiments to search for hidden sources of loss. This experience indicates precisely why David is ready for a transition to independence; his technical accomplishments and leadership abilities will serve him well in his next phase.

Mentoring and Training: David is ready to serve as a mentor of early career scientists. I make a significant investment in mentoring and supporting postdoctoral fellows; this includes offering sustained professional development opportunities in my group. Since starting at GT in 2007, I have mentored a total of 16 postdoctoral fellows of which 5 are current. Of the 11 former fellows, 8 obtained tenure-track faculty positions and three went on to research scientist positions. These placements reflect a collaboratively designed mentoring plan, specifically tailored to the postdoctoral fellow, including research, professional development, and teaching goals, based on general guidelines contained in the BWF-HHMI publication: "Making the Right Moves". David has had multiple targeted teaching and mentoring opportunities that ensure David has a diverse and broad set of career relevant skill sets to prepare him to make the transition to independence. For example, David currently serves as an additional mentor to multiple Quantitative Biosciences PhD students in my group; he has been critical in facilitating research advances for students, and will be a middle author on some of these PhD projects. In addition, he has taken leadership roles in a multi-PI collaboration with the Simons Foundation and is increasingly outspoken on scientific issues and organizational issues with my team. To conclude, David's research proposal is novel and fits into an area of growing excitement and new technologies to probe how viruses modulate phytoplankton population dynamics and marine ecosystem function. David has the ideal mix of skills, technical strengths, independence, passion, and drive to support team. I wholeheartedly support David's application and urge you to give him your most serious consideration.

Sincerely,

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Georgia Institute of Technology
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Blaise Pascal Chair of Excellence ('21-22)
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