

OCEAN TURBULENCE AND MIXING COURSE

STUDENT-LED INSTRUCTION AND AT-SEA EXPERIMENTATION

SUPPLEMENTARY PARTICIPANT SURVEY

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COMCEPTS Participant Survey – Questions and Results

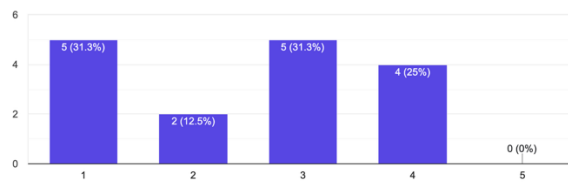
Overview – The course participants were surveyed before and after the class

	Before Course	After Course
Date	Aug 30, 2025	Sept 19, 2025
Number of responses (N)	16	10

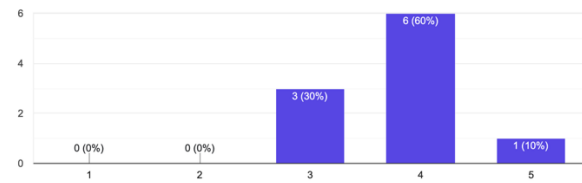
Section 1 - Rate your own knowledge (1 –“I’m a newbie” to 5 - “I’m a pro”)

Q1: “I feel confident using turbulence terminology”

Before

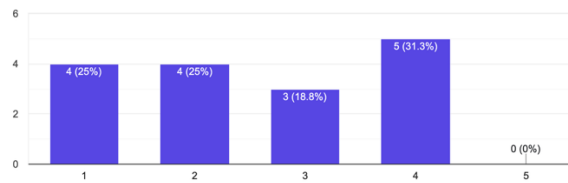


After

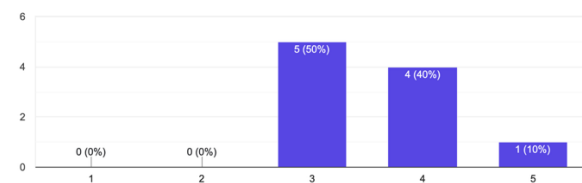


Q2: “I have a decent grasp of fundamental turbulence theory”

Before

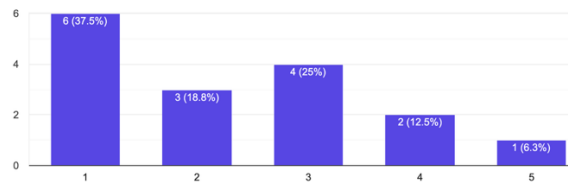


After

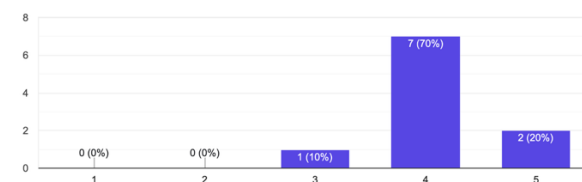


Q3: “I know what goes into collecting turbulence data at sea”

Before

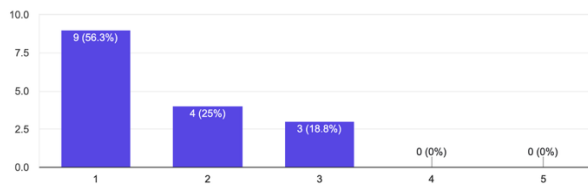


After

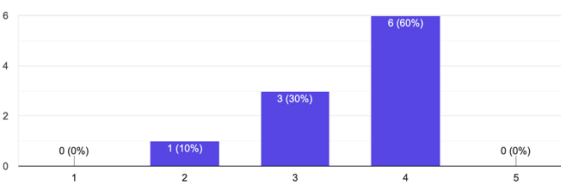


Q4: “I understand the assumptions made in processing of turbulence data”

Before



After



Section 2 – Free Response

	Before	After
Q1: What is the difference between turbulence and mixing?	• I don't know • Turbulence causes mixing, mixing does not occur without turbulence • Not sure • I don't know • Not sure • I think of turbulence as more of a dynamic state of a fluid that describes motions, which can also be one way to enhance mixing • Turbulence transports fluid around, mixing refers to the irreversible diffusive change to a tracer field which is enhanced by turbulence • Mixing involves two or more parts with different characteristics interacting, while turbulence involves just one fluid body in motion (best guess) • Turbulence is a random movement of the particles in a fluid, mixing is a consequence of that • as a total guess: turbulence causes mixing...? • Don't know • Turbulence is chaotic flow, mixing is the	• Mixing is the homogenizing of two water masses. Turbulence stirring caused by instability • turbulence is the chaotic motion of a fluid (which can facilitate mixing) while mixing is dispersion across isopycnals • Turbulence can result in mixing but it doesn't have to • Mixing is irreversible changes to scalar gradients ENHANCED by turbulence • mixing is the process of irreversible homogenizations of properties, turbulence is chaotic/non laminar motion that enhances mixing • Turbulence describes all the chaotic motion, mixing is stretching isopycnals • Turbulence is the chaotic motion of a fluid. Mixing is the exchange of quantities between two fluids. • mixing is the process of moving into an equilibrium state. As an example, given a stratified fluid of

	homogenization of fluid components • Mixing is how scalar quantities are transported and exchange among each other. Turbulence is the term referred for chaotic movement mixing is when this chaotic movement mix the water. • Turbulence is non reversible combination of ocean properties, where mixing could theoretically be undone • Turbulence is a nonlinear process within which characteristic variables of the flow differ dramatically through space and time, in ways which often "feel" or appear chaotic and/or stochastic. Mixing is often a result of turbulence, and describes an irreversible dampening of gradients within a specific quantity due to molecular diffusion, which may be intensified by turbulence.	temperature mixing would be the process of all layers having the same temperature. Turbulence is chaotic motion which can drive mixing. • Turbulence is the chaos in a fluid, but mixing is when this chaos can blend its state characteristics. • Turbulence is the chaotic movements of the flow that act to physically move water of different properties around. Mixing on the other hand is the physical irreversible process of those different properties homogenizing, generally through diffusion. In our case, turbulence generally spreads out fluids to enhance the diffusion of these properties.
Q2: What is an energy cascade?	• I don't know • Wind and temperature gradients • Waves, wind, a bunch of things • velocity/temperature/pressure differences? • Instabilities • Shear, momentum and/or buoyancy forcing, • Lots of things: breaking internal waves, etc • Temperature, salinity, and surface air/sea interactions. • Wind, bottom roughness, breaking of internal waves • shear (??)	• Energy being dissipated through a water column and across isopycnals • energy cascade refers to the dissipation of kinetic energy from large scales to tiny scales • Transfer of energy between scales • How energy transfers from larger scales to smaller scales to eventually dissipation • energy moves from large to small scales and dissipates, due to things like wave-wave interactions and breaking

	• Don't know • The breaking of internal waves, lee waves • Wind, tides, topography • Currents, interaction of waves with topography, eddies, etc • Buoyancy fluxes, wind forcing, breaking internal waves, etc. • Many things. Surface waves, internal waves, macroscopic organisms, currents, eddies, wind flow, geothermal heating, etc.	• Energy moving between spatial scales • It's the transfer of turbulent energy from large to small scales. • Energy moves forward to higher frequencies which then it eventually dissipates into heat or potential energy • It is the pathway to dissipation that the energy takes when a primary force injects energy on large scales, and different mechanisms drive it to smaller scales. • The energy cascade is the transfer of energy from different scales. For turbulence, we generally consider the transfer of energy from large to small until they reach dissipation scales.
Q3: What drives turbulence in the ocean?	• I don't know • Wind and temperature gradients • Waves, wind, a bunch of things • velocity/temperature/pressure differences? • Instabilities • Shear, momentum and/or buoyancy forcing, • Lots of things: breaking internal waves, etc • Temperature, salinity, and surface air/sea interactions. • Wind, bottom roughness, breaking of internal waves • shear (??) • Don't know • The breaking of internal waves, lee waves • Wind, tides, topography	• Temperature and salinity • stratification, surface forcing, topography • Wind...instabilities...internal wave breaking...random fish... • Breaking internal waves, Langmuir turbulence, etc • shear, instabilities • Tides, wind • A lot of things: instabilities, internal waves, wave interactions and interaction with bottom. • Wind stress, double diffusion, internal tides, flows over ridges or seamounts • Motions that inject enough energy to create chaotic movements in the ocean

	• Currents, interaction os waves with topography, eddies, etc • Buoyancy fluxes, wind forcing, breaking internal waves, etc. • Many things. Surface waves, internal waves, macroscopic organisms, currents, eddies, wind flow, geothermal heating, etc.	• A good number of things, but generally, instabilities. The instabilities in flow from shear, buoyancy, and diffusive instabilities act as mechanisms to create turbulence, and thus drive mixing.
Q4: What are some challenges of measuring turbulence in the ocean?	• small scales, fast dissipation • Teeny tiny eddies? • Oh so many things • complexity/too many variables • It's inhomogeneous and small scale • The temporal and spatial scales that it occurs on, the measurements necessary to diagnose turbulence can be difficult to gather, and it's hard to predict when and where a turbulent event will take place in order to capture it • You need finescale measurements of velocity fluctuations with high temporal resolution • Difficult to get synchronized spatial data • Relative small scale in space and time, separate the natural turbulence and the turbulence caused by the equipment • instruments need to be able to measure very fine-scale variability in temp or velocity (without contamination from the platform moving), probably there is also a time • Don't know	• Spatial and time resolution, as well as needing to account for your own movement in the water • instruments are fragile, vessels and cruises are expensive, and turbulent fluids are extremely complex both spatially and temporally • Sensors are really sensitive, turbulent events are frequently transient, regular oceanography time/space aliasing problems, interpreting the freaking data and attributing any turbulence to any particular inciting incident • Low spatial/temporal resolution, can't get too close to the bottom, can't get too close to the surface (surf wake) • fine spatial and temporal resolution, expense of instrumentation • Regionally specific, small scale, varies in time • A lot of theoretical assumptions to be made, issues with instruments • These in situ measurements are expensive and labor intensive.

	• The ocean is huge and turbulence happens on a very small scale • Lots of assumptions to be made, lots of noise • In small scales, how to define and measure • Connecting scales between instruments, shear probes are very fragile • Oftentimes turbulence occurs at very small length scales (m or smaller), and requires expensive microstructure point-wise measurements at specific locations.	• Separate the movement of the instrument from the real movement of the ocean, and define those movements • Some quantities are just difficult or just outright impossible to measure. Part of that is getting high enough resolution from the instruments to resolve these features. Another facet is going back to the assumptions we make. We can only estimate turbulent properties from the values we can measure, so inherently we aren't getting the full picture. Also just scale of operation is a huge issue too.
Q5: What are some assumptions made when measuring turbulence in the ocean?	• I don't know • Good question :) • Not sure • i don't know • Isotropic? • I know the ones in theory (stationary, isotropy, homogeneity, etc.), but I don't know if it carries over to measuring Tulane in the ocean • Probably isotropic? • Don't know! Excited to find out • I'm not sure • as a total guess: empirical relationships between the observed variability and the "dissipation rate"? • Don't know • Frozen flow hypothesis probably • For instance, Taylor's hypothesis • Don't know	• At the smallest scales, direction doesn't matter • Isotropy • isotropy x100 • Isotropy sometimes • isotropy, frozen field, constant mixing efficiency, diffusivity of heat and salt are the same • Isotropy, frozen spectra • Isotropy, Taylor's and Kolmogorov's hypotheses • Turbulence is isotropic, mixing coefficient is constant • Isotropy and self similarity • For small scale stuff, Isotropy is a big one. Outside of that, the TKE equation is based around the Navier-Stokes equations, assuming non-constant density. Or we make use of the Fick diffusion model to get things like Turbulent eddy

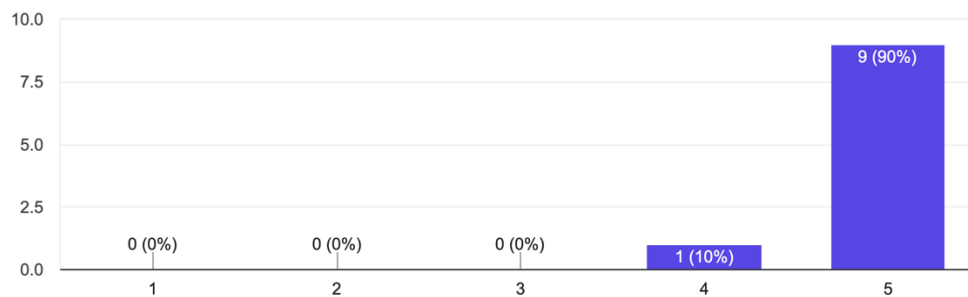
	• Isotropy? • Not sure honestly, but I would guess things like isotropy, statistical homogeneity, possibly a Taylor frozen turbulence assumption for conversion between frequency and wavenumber.	diffusivity. In short, we make a few.
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Section 3: Feedback – This section was only available in the survey after the course

Q1:

COMCEPTS covered concepts (haha!) I was interested in understanding better

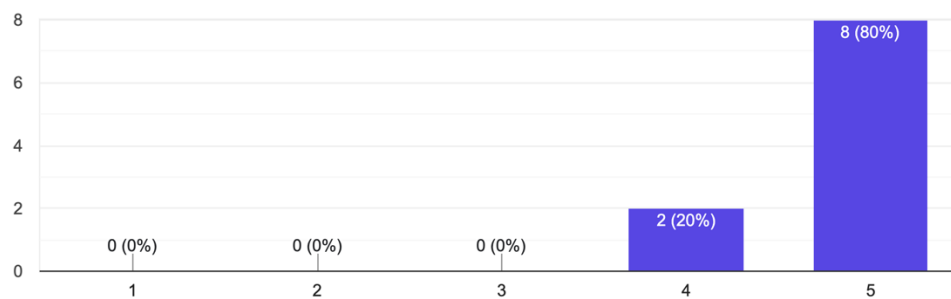
10 responses



Q2:

The course material presented was accessible

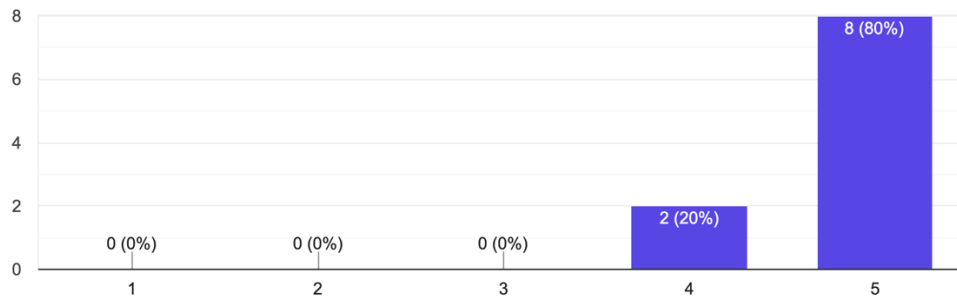
10 responses



Q3:

The cruise helped me understand how different ocean quantities are measured through shipboard profiling

10 responses



Q4: What did you enjoy most in this iteration of COMCEPTS?

- I loved the lectures/classes/seminars, I thought they were really helpful and well put together. I sort of think I came in with slightly more background knowledge than the average person in the course, but I found them to be the perfect level of accessible
- snacks and project work
- Overnight cruise
- I really enjoyed the diversity of lectures and applications of mixing research, I loved the ship time, and I loved the opportunity for networking and teamwork
- Learning about the epsi
- Definitively the guest lectures!
- It was great getting hands on experience during the cruise to see how these measurements are taken. I was grateful for the details of all the slides, as well as having the slides during lecture, so that I can take notes as well as review
- Personally, the ship (I love the sea, and the work dynamic), but academically, the third week, the interaction between each team, and the knowledge of the data treatment
- As both an auditor and guest star, I really enjoyed just seeing how much effort you all put into this. Having a whole 3 week holistic approach to this sort of stuff is unheard of and I think a great opportunity for those that we involved.

Q5: What would you like to see next time?

- No real suggestions at the moment!
- maybe more foundational dynamics or ocean characteristics in the beginning
- This might be specific but I thought the day cruise was sort of messy. I know it was more of a pilot cruise to help the project leads come up with a plan, but I sort of spent the entire

day napping on the back deck. I think it would have felt more productive if there was a little more structure.

- Also maybe projects that had a more narrow scope? They were daunting for 1 wk of analysis and it would have been somewhat more rewarding to have some more solid results (though I know that's not really how the world works)
- I think the length was a challenge, I'm not sure how it could be shortened, but a full week of lectures and a full week of data analysis was hard.
- The data analysis section was stressful to do all in a group. It would be nice to have some individual work time
- More time spent on theory and understanding certain difficult concepts.
- I think in class problem sessions would be great to solidify the subject.
- I think I was pretty well covered! It's hard to condense all this information. But, for my background knowledge, it was perfect.
- This is sort of a tough question, because generally the answers to anything I have are things outside of your control (more money, more student buy in, more time to practice, etc.) which isn't really the helpful stuff to focus on. With that said, I think a few things is just generally figuring out and focusing on nailing the tricky bits for people when it comes to understanding the theory. I think we all knew it was a bit of a fire hose of information the first week, but maybe there is some ways to simplify the delivery of the content. I am happy to chat about next time stuff too, might be easier than just typing this out lol.