KESS and Its Legacies

Report to US CLIVAR

18 July 2012

Meghan Cronin (NOAA PMEL)

• KESS objectives & field program
• Best Practices – http://uskess.org
• A few highlights from KESS research
• Activities since KESS
The overall goal of KESS is to identify and quantify the dynamic and thermodynamic processes governing the variability of and the interaction between the Kuroshio Extension and the recirculation gyres:

– To understand processes coupling the baroclinic and barotropic circulation and variability
– To determine and quantify cross-frontal exchange processes in the Kuroshio Extension
– To determine the processes that govern the strength and structure of the recirculation gyres – its position, elongation, stratification, and subtropical mode water formation within the gyres
KESS Observations
May 2004 – June 2006

- subsurface current meter and profiler moorings
- current & pressure recording inverted echo sounders (CPIES)
- profiling Argo floats
- meteorological buoy (KEO)
- atmospheric soundings
- underway ADCP
- hydrography
- satellite altimetry
- 1/10° POP model
Kuroshio Extension System Study

The warm, northward-flowing waters of the Kuroshio western boundary current leave the Japanese coast to flow eastward into the North Pacific as a free jet—the Kuroshio Extension. The Kuroshio Extension forms a vigorously meandering boundary between the warm subtropical and cold northern waters of the Pacific. A recirculation gyre exists to the south of the Kuroshio Extension. Another may exist to the north. This is also one of the most intense air sea heat exchange regions on the globe, where the warm Kuroshio waters encounter the cold dry air masses coming from the Asian continent. The Kuroshio Extension system exhibits variations which strongly affect North American climate. Among the diverse fields that will benefit from this work are fisheries and climate research, and understanding storm tracks.

Read more –

Science Highlights

KEO Surface buoy
KEO mooring carries a suite of meteorological sensors to measure winds, air temperature, relative humidity, rainfall, and solar and longwave radiation.

SADCP
KEOS cruises included data from a hull mounted Acoustic Doppler Current Profiler (SADCP), which measured the velocity of the upper-ocean currents below the ship.

Recent Updates

AUGUST 21, 2008
CTD data added.

AUGUST 20, 2008
CIFES data added.

JULY 10, 2008
Current Meter data added.

MAY 14, 2008
Moored Profiler data added.

APRIL 29, 2008
New publication added.

MARCH 11, 2008
Presentations added.

DECEMBER 15, 2007
Theory discussion added.

DECEMBER 8, 2007
Modeling results.

NOVEMBER 29, 2007
Slideshow of photos added to each cruise page.

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1/10° POP model information added.

NOVEMBER 13, 2007
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OCTOBER 20, 2007
New Principal Investigators page.

OCTOBER 12, 2007
New look to the site.
Data Products

Argo | CTD | Mooring | KEO Buoy | Model | Other

Argo Profiling Floats
University of Hawaii Argo Profiling Floats Data Page

CFIES Data from GSO/URI

Shown below is the KESS CFIES/PIES array superimposed on Smith and Sandwell bathymetry contoured every 1000 m. The CFIES/PIES were moored in water depths ranging from 3500 m on the western side of the array to 6300 m in the east. Data are available for 46 sites (Sites file lists nominal positions and bottom depths). Site designator is given in the upper left hand corner and IES serial number is listed under the triangles. Black is for CFIES sites, red for PIES sites, magenta specifies sites where only telemetry was taken, and yellow designates where instruments were CFIES in 2005, but PIES in 2006. The measurements were made during April 2004 to July 2006 under the sponsorship of the National Science Foundation. The measured quantities include pressure, vertical acoustic round-trip travel time, and currents. All data files in the CFIES archive are provided in ASCII format.

CONTENTS of HOURLY FILES
There are up to three files for each instrument, where XX is the site designator and YYY is the IES serial number:
- prs/XX_SNYYY.dat -- pressure in decibars
- tau/XX_SNYYY.dat -- vertical acoustic travel time in seconds
- currents/XX_SNYYY.dat -- u,v velocities in cm/second

These are the highest quality versions of the data after the least amount of processing. Large data spikes (outliers) and long term drifts have been removed from these records. Details of the processing are provided in the data report. Each file contains year, month, day, hour, minute, second and either pressure, travel time or currents. Missing data values are indicated by NaN.

CONTENTS of 72 HR LOWPASSED FILES
There are up to three files for each instrument, where XX is the site designator:
- prs/XX.dat -- leveled, demeaned pressure in decibars
- tau/XX.dat -- vertical acoustic travel time from 0 to 1440 dbar in seconds
- currents/XX.dat -- u,v velocities in cm/sec
Velocity Section

SSH contour used as proxy for the Kuroshio Extension jet axis

Provided by S. Jayne (WHOI)
Example of external eddy triggering growth

Upper meanders (trough c, black contours; crest d, gray contours) propagate downstream along the jet.
Deep eddies (highs: red; lows: blue) propagate NNE-SSW across the jet.

Growth occurs from interaction with pre-existing deep eddies if they encounter each other with the deep offset 1/6-1/4 wavelength ahead of the upper meander.

Tracey et al. JPO 2012

Provided by R. Watts and K. Donohue (URI/GSO)
Bond et al. JGR 2011: Upper-ocean response to typhoon Choi-Wan as measured by the Kuroshio Extension Observatory (KEO) mooring.

Impulsive winds generated NIOs. Inertial pumping caused heaving for at least a week down to nearly 500m.

Provided by M. Cronin (NOAA PMEL)
Cronin et al. DSR II In Press: Formation and erosion of the seasonal thermocline in the Kuroshio Extension recirculation gyre.

Provided by M. Cronin (NOAA PMEL)
Subtropical Mode Water
KEO (surface) and KESS-7 (subsurface) moorings

**Temperature**

![Temperature chart](chart.jpg)

**Potential vorticity**

![Potential vorticity chart](chart.jpg)

**STMW:**

$$Q = -\frac{f}{\rho} \frac{\partial \sigma_\theta}{\partial z} < 2 \times 10^{-10}$$

Provided by L. Rainville (APL/UW)
North Pacific Subtropical Mode Water

Masuzawa (1969)

Quasi-decadal variability of NPSTMW volume:
volume min toward the end of each decade,
at the time of PDO phase shift (from warm to cool)
(e.g. Davis et al., 2011)

Observations: Argo floats

Eddy-resolving (0.1°) POP model results

Provided by I. Cerovecki (Scripps)
Atmospheric Sounding Probes Ocean's Effect on Climate

Y. Tanimoto (2009, J Climate)

Cold cross-frontal advection under northerly winds

Stratus cloud with an elevated base capped by a primary inversion

Warm advection under the southerlies

Fog capped by a surface inversion

Provided by S.-P. Xie
JAMSTEC-KEO

US CLIVAR WBC Working Group

NOAA KEO

NSF Kuroshio Extension System Study (KESS)

JAMSTEC-KEO

Hot-Spot: A new Japanese Air-Sea Interaction Exp’t
Lead PI: H. Nakamura

JAMSTEC S1

Biogeochemical mooring

mid-jet

Hot-Spot KEO

Summer monsoon/Kuroshio

Winter monsoon/Oyashio

Troposphere/stratosphere

Heat

Qnet (W/m²)

JKEO

HotSpot KEO

KEO

S1

136°E 140°E 144°E 148°E 152°E 156°E 160°E

28°N 32°N 36°N 40°N

135°E 140°E 145°E 150°E 155°E


2004
In 2014: Mode water Ventilation Experiment (MoVE)
Lead PI: Shang-Ping Xie (with funding from China)
KESS: Kuroshio Extension System Study

Kuroshio Extension System Study
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