STUDY TITLE: Forcing Functions Governing Salt Transport Processes in OCS Navigation Canals and the Surrounding Wetland Landscape Using Houma Navigation Canal (HNC) as a Surrogate Canal

REPORT TITLE: Forcing Functions Governing Salt Transport Processes in Coastal Navigation Canals and Connectivity to Surrounding Marshes in South Louisiana Using Houma Navigation Canal as a Surrogate

CONTRACT NUMBER: M10PG00037

SPONSORING OCS REGION: Gulf of Mexico

APPLICABLE PLANNING AREA: Central

FISCAL YEARS OF PROJECT FUNDING: 2010-2012

COMPLETION DATE OF REPORT: June 2014

COSTS: $278,531.45

PROJECT MANAGER: Gregg Snedden

AFFILIATION: United States Geological Survey National Wetlands Center

ADDRESS: USGS National Wetlands Center, Baton Rouge, LA 70803

PRINCIPAL INVESTIGATOR: Gregg A. Snedden

KEY WORDS: salt transport, saltwater intrusion, estuary, current velocity, salinity

BACKGROUND: US Department of the Interior Minerals Management Service (now the Bureau of Ocean Energy Management [BOEM]) funded and completed several studies dealing with the canal widening and land loss issues. The first study entitled “The Outer Continental Shelf (OCS)–Related Pipelines and Navigation Canals in the Western and Central Gulf of Mexico: Relative Impacts on Wetland Habitats and Effectiveness of Mitigation” was completed in 2007. This comparative study basically identified localized loss rates and patterns within the vicinity of OCS pipeline and navigation canals and compared them to regional loss patterns in various sub areas (Chenier plain, Delta plain, etc.) of the Central and Western Planning areas and how they responded over time with and without mitigation.

A second study, “Influence of the Houma Navigation Canal (HNC) on Salinity Patterns and Landscape Configuration in Coastal Louisiana” (Steyer et al. 2008), evaluated how an OCS navigation canal contributed to changes in salinity and wetland landscape patterns in southeastern Louisiana. The study examined the patterns of marsh deterioration as a function of hydrological connectivity to higher salinity waters. No direct relationship was established due to variability of marsh loss adjacent to HNC (3KM buffer), lack of current data and models. Though there may be some influence on marsh degradation from the canal, the degree and distance of the influence was not detectible. Though both studies provide insight and perspective into the relationship between salinity and land loss, both studies relied on old in situ salinity data and photo and thematic mapper satellite imagery comparisons to estimate the salinity and land loss correlations.

Understanding how circulation and mixing processes in the HNC influence the exchange of salt among the Terrebonne marshes and coastal ocean and how those processes are modulated by external physical processes is critical to anticipating effects of future actions and circumstances such as deepening the channel, placement of locks in the channel, changes in freshwater discharge down the channel, changes in OCS vessel traffic volume, and sea level rise. Though periods of minimal tidal stirring (e.g., neap tides) or strong buoyancy forcing (e.g., high freshwater inputs) both can enhance gravitational circulation and salt wedge development (Griffin and LeBlond 1990; Ribeiro et al. 2004), their effects on vertically-averaged advective salt transport are typically opposite. Stratification associated with weak tidal stirring tends to impede downestuary salt transport; stratification associated with buoyancy forcing tends to enhance it (Medeiros and Kjerfve 2005; Miranda et al 2005). Periods increased marsh salinities may result from prolonged episodes of strong upestuary salt flux in the HNC.

This study intends to build on previous MMS-funded studies by investigating salt flux variability through the HNC and how external physical factors such as buoyancy forcing and mixing from tidal stirring and OCS vessel wakes influence dispersive and advective fluxes through the HNC. Additionally, this work will monitor salt flux between the HNC and its flanking marshes, estimate the variability of this flux over different processes (e.g., vessel wakes, tidal sloshing, meteorological forcing, seasonal variability) that occur over a broad spectrum of timescales, and evaluate the impact of this salt flux on salinity in those marshes.

OBJECTIVES: The objectives of this study were to evaluate:

1) how salt transport in outer continental shelf (OCS) navigation canals is governed by buoyancy inputs, wind, tidal stirring, and OCS vessel traffic

2) how salt flux between OCS navigation canals and the fringing marsh landscape relates to the extent of salt wedge development and salinity in the canal, and how OCS vessel traffic may augment or inhibit this salt flux

3) how salinity fluctuations in the fringing marsh landscapes vary with salt flux measured through cuts or channels that connect them to nearby OCS navigation canals

DESCRIPTION: This study quantifies salt transport processes and salinity variability in the HNC and surrounding Terrebonne marshes. Data collected for this study included time-series data of salinity and velocity in the HNC, monthly salinity-depth profiles along the length of the channel, hourly vertical profiles of velocity and salinity over multiple tidal cycles, and salinity time series data at three locations in the surrounding marshes along a transect of increasing distance from the HNC.

SIGNIFICANT CONCLUSIONS:

1) The import of saline shelf waters into the HNC and their subsequent transport up the HNC channel occur primarily through wind-driven barotropic currents driven by alongshore wind stress over shelf waters adjacent to Terrebonne Bay.

2) The salt flux decomposition results indicate that the advective term was the largest component to the salt balance during all tidal cycles sampled, though less so during equatorial tides that occur during low river flow. Under such conditions, salt flux brought about by gravitational circulation becomes increasingly important, in one case nearly balancing the outflow induced by advection. The tidal pumping term tended to be most important during tropic tides, when tidal excursion distances were greatest and entrained salt particles could be transported furthest by tidal currents.

3) Along-channel salinity structure in the HNC can vary widely, both in terms of vertical (salt wedge) structure and in terms of saltwater intrusion length. This length is mainly governed by Atchafalaya River discharge, but also by alongshore winds stress. Increased river flows decrease saltwater intrusion length, and wind stress toward the east can further reduce it. Vertical salinity stratification responded strongly to variations in tidal stirring power over the course of the tropic-equatorial cycle.

4) The HNC serves as the primary conduit for salinity intrusion to surrounding marshes. Marsh salinities responded much more strongly to salinity variations in the HNC than to variations at the seaward extent of the Terrebonne marshes.

5) The effect of vessel wakes on the delivery of salt from the HNC into surrounding marshes appears to be minimal.

STUDY RESULTS: Two modes of vertical current structure were identified. The first mode, comprising 90% of the total flow field variability, strongly resembled a barotropic current structure and was coherent with alongshelf wind stress over the coastal Gulf of Mexico. The second mode was indicative of gravitational circulation and was linked to variability in tidal stirring and the longitudinal salinity gradients along the channel’s length. Diffusive process were dominant drivers of upestuary salt transport, except during periods of minimal tidal stirring when gravitational circulation became more important. Salinity in the surrounding marshes was much more responsive to salinity variations in the HNC than it was to variations in the lower Terrebonne marshes, suggesting that the HNC is the primary conduit for saltwater intrusion to the middle Terrebonne marshes. Finally, salt transport to the middle Terrebonne marshes directly associated with vessel wakes was negligible.

ACCESS NUMBER: 00037

STUDY PRODUCT: Snedden, G. A. 2014. Forcing functions governing salt transport processes in coastal navigation canals and connectivity to surrounding marshes in South Louisiana using Houma Navigation Canal as a surrogate. U.S. Dept. of the Interior, Bureau of Ocean Energy Management, Gulf of Mexico OCS Region, New Orleans, Louisiana. OCS Study BOEM 2014-607. 88 pp.